mild. The winter was unusually favorable for the stock interests of Wyoming, and in many sections the losses were exceedingly small. An ample amount of snow over the western and northern sections of the State, assures a good water supply for the coming summer in those sections. Over the southeastern part the supply of snow was deficient, and a shortage of water was anticipated.—*W. S. Palmer.*

SUMMARY OF TEMPERATURE AND PRECIPITATION BY SECTIONS, MARCH, 1904.

In the following table are given, for the various sections of the Climate and Crop Service of the Weather Bureau, the average temperature and rainfall, the stations reporting the highest and lowest temperatures with dates of occurrence, the stations reporting greatest and least monthly precipitation, and other data, as indicated by the several headings.

The mean temperatures for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperature and precipitation are based only on records from stations that have ten or more years of observation. Of course the number of such records is smaller than the total number of stations.

Section.	Temperature—in degrees Fahrenheit.								Precipitation—in inches and hundredths.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
Alabama	58.2	−3.0	Clanton Dothan	89 89	22 24	Oneonto	23	9	3.69	−2.20	Madison	8.50	Clanton	1.05
Arizona	57.2	+3.2	Champies Camp	105	8	Flagstaff	0	24	0.28	−0.49	Flagstaff	1.39	6 stations	0.00
Arkansas	55.4	+3.2	Amity, Ozark	90	21	Pond	12	4	5.64	+0.42	Witt Springs	8.47	Pond	1.88
California	51.1	−0.9	Salton Volcano Springs	98 98	7 7	Bodie	−12	12	8.52	+4.33	Bowmans Dam	39.51	4 stations	0.00
Colorado	38.1	+4.4	Lamar	84	2	Antelope Springs	−17	26	1.35	−0.18	Ruby	6.65	Lamar	0.01
Florida	67.5	+2.8	Macclenny	94	22	Tallahassee Wausau	30 30	16 5	1.62	−1.76	Bonifay	4.00	Flamingo	T.
Georgia	57.8	+2.4	Jesup	92	23	Clayton Tallapoosa	22 22	16 28	2.73	−2.33	Clayton	6.64	Americus	0.83
Idaho	34.7	......	Pollock	73	24	Lake	−14	24	4.37	......	Hailey	7.73	Milner	1.32
Illinois	40.0	+0.9	Plum Hill	80	31	Lanark	9	4	6.20	+2.71	Mt. Carmel	12.84	Lanark	2.68
Indiana	40.7	+1.5	Madison, Washington. Rome	80 80	24 31	Valparaiso Angola, South Bend. Crawfordsville	11 11 11	3 4 4	8.09	+4.32	Washington	13.73	Topeka	3.22
Iowa	34.8	+2.4	Ottumwa	78	23	Columbus Junction	−3	3	2.19	+0.35	Bedford	4.57	Ida Grove, Sioux C'y	0.50
Kansas	46.9	+4.9	Sedan	93	2	Wallace	−4	3	1.45	−0.13	Fort Leavenworth	4.24	4 stations	T.
Kentucky	47.7	+1.5	Mayfield	88	21	Anchorage	12	4	6.26	+1.15	Owensboro	8.99	Williamsburg	3.78
Louisiana	64.2	+3.9	Franklin Robeline	90 90	31 2	Calhoun	24	4	4.22	−0.61	Collinston	6.78	Jennings	2.00
Maryland and Delaware	41.2	−0.8	Boettcherville, Md	87	25	Oakland, Md	5	17, 18	3.04	−0.63	Cambridge, Md	4.24	Westernport, Md	1.13
Michigan	28.1	−0.5	Adrian	70	31	Humboldt	−31	4	3.10	+1.00	South Haven	7.32	Mancelona	0.42
Minnesota	24.8	+0.1	Lu Verne	63	24	Pokegama Falls	−41	4	1.51	+0.05	Mount Iron	3.72	Pipestone	0.08
Mississippi	60.2	+3.4	Port Gibson	89	22	Corinth	21	4	5.18	−0.60	Duck Hill	8.77	Macon	2.25
Missouri	44.8	+2.5	Dean	87	21	Montreal	8	4	4.14	+0.89	Ironton	11.49	Lamar	1.48
Montana	25.1	−4.5	Lame Deer	63	7	Wolsey	−36	26	1.90	+0.98	Troy	4.51	Boulder	0.61
Nebraska	38.8	+4.3	Alma Fairbury	84 84	18 2	Agate	−7	3	0.53	−0.57	Fairbury (near)	2.69	5 stations	T.
Nevada	39.7	+3.0	Sodaville	80	19	Ely Geyser	0 0	23 24	1.69	+0.11	Lewer's Ranch	9.10	Fallon	T.
New England*	30.2	−0.8	Chestnut Hill, Mass.	71	26	Fort Fairfield, Me	−23	4	2.79	−0.73	Bar Harbor, Me	5.37	Fort Fairfield, Me	0.95
New Jersey	37.2	−1.1	Barnegat, Tuckerton	72	26	Charlotteburg	1	5	3.43	−0.73	Imlaystown	4.76	Pleasantville	2.02
New Mexico	47.6	+3.7	Carlsbad	91	2	Winsors	5	13	0.19	−0.22	Fort Wingate	1.40	12 stations	0.00
New York	29.8	−1.4	Appleton Primrose Ripley	66 66 66	25 26 22	Indian Lake	−25	5	3.13	+0.10	Adams Center	6.24	Plattsburg	0.20
North Carolina	50.5	+1.9	Rockingham	85	20	Linville	14	29	4.11	−0.50	Horse Cove	8.14	Rockingham	2.13
North Dakota	18.0	+6.9	Fort Yates	64	1	Milton	−28	3	1.33	+0.38	Pembina	2.24	Ellendale	0.30
Ohio	39.7	+0.8	Thurman	86	25	Hillhouse	−1	4	5.73	+2.35	Green	8.84	Philo	2.44
Oklahoma and Indian Territories.	56.1	+5.9	Healdton, Ind. T	99	21	Binger, Chandler, Okla.	10	4	2.17	−1.08	Coalgate, Ind. T	4.60	3 stations	0.00
Oregon	40.3	−2.0	Pendleton	75	7	Joseph	7	2	8.85	+4.73	Buckhorn Farm	26.47	Riverside	0.60
Pennsylvania	36.0	−10.4	Johnsto'n, Unionto'n	80	25	Dushore	−2	17	4.29	+0.53	Beaver Dam	7.02	Scranton	2.10
Porto Rico	73.2	......	Bayamon Manati	95 95	9 20	Adjuntas Caguas	50 50	4 14	7.38	......	Cidra	19.45	Santa Isabel	2.76
South Carolina	56.2	+1.6	Blackville	87	1	Greenville	23	16, 17	3.42	−0.41	Walhalla	5.52	Charleston	1.54
South Dakota	31.0	+3.0	Armour	76	24	Leola	−18	3	0.37	−0.99	Leola	1.50	3 stations	T.
Tennessee	51.4	+2.9	Franklin, Iron City. Lebanon Rogersville	83 83 83	22 22 25	Rugby	13	4	6.24	+0.56	Sewanee	10.08	Bristol	3.10
Texas	64.8	+5.9	Cotulla	106	11	Amarillo	15	3	1.05	−1.17	Arthur City	6.02	28 stations	0.00
Utah	39.9	+1.6	Green River	90	14	Ranch	−10	22	2.33	+0.91	Park City	7.85	2 stations	T.
Virginia	45.7	−0.1	Cape Henry	80	26	Burkes Garden Hot Springs	11 11	4 28	3.08	−0.81	Big Stone Gap	5.20	Richmond	1.28
Washington	38.0	−3.0	Mottingers Ranch	70	7	Republic	−4	2	5.09	+2.61	Clear Water	18.33	Ephrata	0.50
West Virginia	43.8	+2.6	Logan	86	22	Ryan	7	4	4.12	+0.93	Pickens	6.10	Moorefield	1.38
Wisconsin	28.0	−0.8	Beloit	60	24	Butternut, Hayward	−24	4	2.36	+0.41	Milwaukee	5.46	Grantsburg	0.65
Wyoming	30.1	+2.1	Fort Laramie Pine Bluff	70 70	18 1	Daniel	−26	3	2.13	+0.10	Battle	9.10	Pine Bluff	T.

* Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut.

SPECIAL ARTICLES.

THE DIMINUTION OF THE INTENSITY OF SOLAR RADIATION DURING THE YEARS 1902 AND 1903 AT WARSAW, POLAND, RUSSIA.

By LADISLAS GORCZYNSKI.

[Translated from Comptes Rendus, Paris, February 1, 1904. T. CXXXVIII, pp. 255-258.]

In his communication of the 26th of March, 1903, M. Henri Dufour was the first to announce the fact that the intensity of the solar radiation, as received at the surface of the earth, had experienced a considerable diminution since the beginning of the year 1903.[1]

Basing his conclusions on the observations that had been made at Lausanne and at Clarens[2] with the Crova actinometer,

[1] This fact was also announced independently by Mr. H. H. Kimball, as the result of his own observations at Asheville, N. C., during the years 1902 and 1903, but his publication of the fact was delayed a short time. See his note in Monthly Weather Review, May, 1903, p. 232, which article was communicated for publication on April 15, 1903. This fact had also been simultaneously observed at Washington at the Astrophysical Observatory of the Smithsonian Institution. See article by Mr. C. G. Abbot, Monthly Weather Review, December, 1903, p. 587. Similar irregularities had also been pointed out by Mr. Abbot in the Monthly Weather Review, April, 1902, p. 178, as revealed by observations at Montpellier, France.—ED.

[2] On the northeast shore of Lake Geneva, 20 miles east-southeast of Lausanne.

Dufour finds that the diminution of intensity began in December, 1902, that it increased up to March, 1903, and then gradually diminished.

The existence of an unusual atmospheric opacity for several months is also confirmed by the measurements made by A. Gockel[3] (Met. Zeit., 1903, p. 328) and also by the observations of Max. Wolf[4] at Heidelberg (Vierteljahrschrift d. Astron. Gesellschaft, Year 38, part 2). Finally, the diminution of the transparency of the layers of air is also confirmed by S. P. Langley at Washington (Nature, LXIX, p. 5, November 5, 1903).

The diminution of intensity of solar radiation as measured at the surface of the globe has also been confirmed at Warsaw, where systematic observations have been made since December, 1900, with an actinometer of the Ångström-Chwolson pattern. The result of these measurements, undertaken for the purpose of studying and explaining the annual variations of insolation, have been published, in so far as concerns the years 1901 and 1902, in the "Etudes sur la marche annuelle de l'insolation" (Bulletin Internat. de l'Acad. des Sciences de Cracovie, p. 465-503, July, 1903). In this present communication, I will cite only those numbers for the years 1901, 1902, and 1903 that serve to demonstrate the fact of the diminution of intensity with which we are at present concerned.

I present in Table 1 the monthly means of the intensity at Warsaw, expressed in gram calories per square centimeter per minute, accompanied by the corresponding monthly values of the absolute humidity. With these means is given also, in Table 2, the maximum values of the intensity of the radiation (reduced to the average altitude of the sun at Warsaw at the middle of each month) for each consecutive month during the period 1901–1903, inclusive. The last three columns of Tables 1 and 2 indicate the differences between preceding and following years, e. g., 1902 minus 1901 and 1903 minus 1902; these differences are reduced to a common absolute humidity by the use of the coefficient of reduction to a standard humidity, namely, $\Delta = 0.02$.

TABLE 1.—*Average insolation and absolute humidity observed at Warsaw.*

Month.	1901. Monthly means.		1902. Monthly means.		1903. Monthly means.		Differences.		
	Insolation.	Absolute humidity.	Insolation.	Absolute humidity.	Insolation.	Absolute humidity.	1902 minus 1901.	1903 minus 1902.	1903 minus 1901.
January	1.04	3.7	0.95	4.1	0.80	3.0	−0.08	−0.17	−0.25
February	1.29	2.3	1.16	3.3	0.92	3.9	−0.11	−0.23	−0.34
March	1.25	5.3	1.33	4.3	1.03	5.9	+0.06	−0.27	−0.21
April	1.40	5.7	1.36	4.3	1.11	5.6	−0.01	−0.22	−0.23
May	1.38	7.8	1.26	6.2	1.08	7.9	−0.15	−0.15	−0.30
June	1.36	13.2	1.22	7.1	1.21	9.2	−0.26	+0.03	−0.23
July	1.36	11.3	1.24	8.8	1.12	10.5	−0.19	−0.07	−0.26
August	1.28	12.4	1.19	9.0	1.08	12.1	−0.15	−0.05	−0.21
September	1.32	9.5	1.24	7.3	1.07	9.1	−0.12	−0.13	−0.25
October	1.23	8.6	1.09	4.2	1.01	7.2	−0.23	−0.02	−0.23
November	1.13	3.7	0.96	3.0	*	*	−0.18	*	*
December	1.09	5.6	0.79	1.9	0.71	2.1	−0.37	−0.08	−0.45
Year	1.29	8.5	1.15	5.6	0.96	7.3	−0.20	−0.16	−0.36

From the examination of these tables it results that a very considerable diminution in insolation began at Warsaw in the month of May, 1902 (consequently earlier than December, 1902), and persisted month by month during this year and the following, attaining a maximum diminution in the spring of 1903. Toward the end of this latter year, the process of diminution, compared with the figures for 1902, seems to have stopped, but the absolute values continue to be low compared with those of 1901. The cause of the increase in the opacity of the atmosphere for solar radiation is not as yet clear. Dufour correlates this fact with the recent eruption at Martinique, but the extraordinary dust showers that have many times visited Europe during these three years also suggest themselves as a possible cause. However, these can only at present be suppositions whose correctness can not yet be demonstrated, because of the want of more complete and positive data.

TABLE 2.—*Maximum insolation observed at Warsaw, and accompanying absolute humidity*

Month.	1901.		1902.		1903.		Differences.		
	Insolation.	Absolute humidity.	Insolation.	Absolute humidity.	Insolation.	Absolute humidity.	1902 minus 1901.	1903 minus 1902.	1903 minus 1901.
January	1.06	3.8	0.99	5.0	0.89	1.9	−0.05	−0.16	−0.21
February	1.41	1.8	1.30	2.6	0.96	2.6	−0.09	−0.34	−0.43
March	1.28	3.7	1.50	1.7	1.08	5.1	+0.18	−0.35	−0.17
April	1.50	4.7	1.47	3.4	1.11	5.6	−0.06	−0.32	−0.38
May	1.51	4.5	1.32	4.3	1.12	4.8	−0.19	−0.19	−0.38
June	1.46	7.1	1.34	7.9	1.25	9.6	−0.10	−0.06	−0.16
July	1.45	8.2	1.37	6.2	1.22	8.8	−0.12	−0.10	−0.22
August	1.38	12.4	1.28	6.5	1.09	12.9	−0.22	−0.06	−0.28
September	1.37	7.8	1.39	4.0	1.13	7.1	−0.06	−0.20	−0.26
October	1.36	5.0	1.19	4.2	1.13	8.7	−0.19	+0.03	−0.16
November	1.18	4.1	1.03	1.7	*	*	−0.20	*	*
December	1.13	3.0	0.83	2.6	0.80	3.3	−0.31	−0.02	−0.33

* During the month of November, 1903, there was not a single day at Warsaw clear enough to permit actinometric measurements.

The following additional observations on this subject are added for the information of the reader.—ED.

In the Meteorologische Zeitung, July, 1903, vol. 20, p. 328, Dr. A. Gockel, of Freiburg, in Switzerland, says:

It may perhaps be of interest if I add that I myself in the course of some measurements of the ultra violet radiation, using the actinometer of Elster and Geitel, have made the same observation, namely, the diminution of the insolation. On the best days of this past winter, 1902–3, after 11 a. m., the sky almost regularly became covered with a layer of haze that scarcely affected the brightness as observed with the eye, but changed the deep blue of the sky into a somewhat paler tint, and on many days reduced the ultra violet radiation to one-half of its normal value. This absorbing haze can not belong to the lower stratum of the atmosphere, since, in the first place, when the sun's altitude was less than 25°, the radiation was quite normal, and secondly, I have frequently observed the summit of the Bernese Alps, 4000 meters high, with a rare degree of clearness on those days on which the depression of the midday insolation was very pronounced.

The astrophysical division of the splendid observatory of the Grand Duke of Baden, located at Heidelberg, is under the direction of Prof. Max. Wolf, and is located on the summit of Königstuhl a short distance from the famous university. The astronomical section of the observatory, or the "astrometrische division," as it is more specifically called, is under the direction of Prof. W. Valentine. In the latter section, everything bearing on the measurement of the positions of the stars is elaborately observed; this includes the changes in the ground produced by earthquakes and the changes in latitude due to the movements of the earth's axis. In the astrophysical section, under Professor Wolf, the complete meteorological record is maintained; photographs of the sky are made every clear night; the transparency of the atmosphere, the radiation from the sun, the study of the planets by photography, spectroscopy, and photometry, the observations of nebulæ and fixed stars, in fact whatever bears on the nature of the celestial bodies are all carefully recorded. In the course of his annual report on these matters for the year 1902 Professor Wolf says (Vierteljahrsschrift Astronomische Gesellschaft, 1903, 38 Jahrgang, p. 117):

The most interesting meteorological event during 1902 was the unexpected splendor of the twilight phenomena, which attained nearly the same development as in the year 1884. The first purple twilight was observed by us on the 17th of June. The phenomena followed the same order as described in such a masterly manner by von Bezold. After the 17th of June, the complete succession of phenomena was observed on every clear evening until July 6; after that date only the ruby red color could be observed, but much brighter than in other years. The two purple lights and the purple counter-twilight glow were best developed on the 26th of June. On the 24th of July, there began a second feebler development of the purple light, which lasted the whole year through,

[3] See reprint at end of this article.—ED. [4] Ibid.

with alternating feebler and stronger developments. A maximum in October was especially well marked. It is remarkable that Bishop's ring could not be certainly recognized until January, 1903; it was measured around both the sun and moon, respectively.

Of course, an effort was made to bring these phenomena into connection with the outburst of volcanoes in the West Indies. Now the first violent eruption of Mount Pelée occurred on the 8th of May, 1902. It would, therefore, have required six weeks for the dust to arrive at that stratum of air above Heidelberg where the purple light originates. But other observations, namely the daily observations of insolation, seem to indicate that the dust had hovered over us somewhat earlier. The following are the pentadal averages of the observations of the radiation thermometer. [Presumably the black bulb in vacuo of the Arago-Davy actinometer.—ED.]

Pentads.	Mean of the radiation maxima.
	°C.
May 26-31	45.8
June 1-5	49.9
June 6-10	39.3
June 11-15	39.1
June 16-20	40.0
June 21-25	41.2
June 26-30	46.4

From these figures it would seem probable that the obscuration due to the dust occurred over this observatory about or before the 10th of June, which corresponds to a velocity of five weeks instead of the six weeks above given.

During the whole of the second half of the year the astronomical transparency of the atmosphere was much less than usual.

One must be very careful not to misinterpret the readings of the Arago-Davy actinometer. The correct theory of the action of this instrument was first given by Prof. William Ferrel in his memoir on the temperature of the atmosphere and earth's surface, pp. 34-48, "Professional papers of the Signal Service, No. XIII, Washington, 1884." See also Ferrel's "Recent advances;" also Prof. Winslow Upton's report on the actinometric observations made during the United States Eclipse Expedition to the Caroline Islands. According to Ferrel the insolation must not be measured by the mere reading of the maximum thermometer, but depends upon both this and the difference between the bright and black bulb, and must be computed by the formula

$$I = 4.584\mu^{\theta_1}\left(\mu^{\theta-\theta_1} - 1\right)\frac{1}{1-4\rho_1}$$

in which he assumes that the two conjugate thermometers have spherical bulbs. ρ_1 is the relative absorbing power of the bright bulb as compared with the black bulb, and must be determined for each instrument. θ is the temperature of the black bulb, θ_1 is the temperature of the bright bulb, μ is the constant, 1.0077, as determined by Dulong and Petit. The following table, quoted from Ferrel, illustrates the working of this formula:

Values of I for different values of θ and θ_1.

θ_1.	$\theta-\theta_1$.			
	10° C.	20° C.	30° C.	40° C.
°C.				
−10	0.339	0.705	1.099	1.525
0	0.366	0.761	1.187	1.646
+10	0.395	0.822	1.282	1.778
20	0.426	0.887	1.385	1.920
30	0.460	0.958	1.495	2.073

ED.

ORIGIN OF AMERICAN COLD WAVES.

In a letter of January 26 to Prof. R. F. Stupart, the Editor said:

I have just read an old excerpt from the Cœur d'Alene Sun.

We have taken careful note of the development of these cold waves in the Klondike, and it usually takes three weeks for them to travel down to the weather stations at Edmonton, Qu'Appelle, and Havre.

I myself suppose that the cold of cold waves is due entirely to the radiation of heat from the lower strata of the atmosphere to ground and to the clear sky overhead, as explained in my article on "Atmospheric radiation and its importance in meteorology," published in the American Journal of Science in 1892, and reprinted in the American Meteorological Journal, vol. 8, p. 537. I suppose, therefore, that a cold wave may originate anywhere along the western slope of the Rocky Mountains, and its coldness when it reaches Montana would depend on the slowness with which it has moved southward, so that it may possibly be true that the very coldest temperatures come with cold waves that have taken three weeks to move from the Klondike southward. I am rather inclined to doubt whether any of our cold waves, at least those worthy the name, originate north of British America, but that they all begin with the clear air that flows over the northern part of the Rocky Mountain range.

Under date of February 9, 1904, Professor Stupart replied as follows:

I am studying the question, using the data from Dawson, Fort Good Hope, Chippewyan, Fort Churchill, York Factory, Edmonton, and Winnipeg. In a short time I shall hope to send you something further. I am almost satisfied that the Cœur d'Alene Sun is astray in supposing that it takes three weeks for cold waves to travel from the Klondike to Alberta and Havre. There is, I think, some ground for a belief that in many seasons the cold waves take about six days. This is indicated in the winters of 1901-2 and 1902-3, but it is certainly true that in some seasons waves of intense cold which are experienced in the far north never reach Alberta or even Winnipeg. This present winter, in December the coldest weather seems to have occurred simultaneously at Dawson, Edmonton, and Winnipeg. In January the greatest cold wave set in at Dawson on the 9th or 10th, and the coldest weather of the month began at Edmonton on the 15th. This is also about six days. But this present month another great cold wave set in over the Yukon on the 2d, and almost coincidently the weather turned decidedly cold at Edmonton.

I spent the winter of 1884-1885 in Hudson Strait on the barren grounds. February of that winter was there exceedingly mild for that region, while in Toronto it was the coldest month, but one, recorded in seventy years. I quite agree with you that probably none of the cold waves originate north of British America, but it appears to me that they may originate almost anywhere over the more northern portions of the continent. The cold waves which have passed across the Great Lakes and the St. Lawrence Valley this winter do not appear to have originated in the far northwest, or at least they have become much more intense as they approached Ontario and Quebec.

With regard to the cold of cold waves being entirely due to the radiation of heat from the lower strata of atmosphere to the clear sky overhead, I can not offer other explanation, but at the same time, I doubt whether it is the full explanation. In some winters great cold waves persistently form, while in other years, with barometric and cloud conditions as far as we can judge almost identical, the resulting cold waves are relatively unimportant.

I do not believe in moon or planets having any appreciable effect on the terrestrial weather. The sun alone is to be considered, and I hope there is now some ground for belief that the physicist may shortly give us information regarding solar radiations which may assist in solving some of the perplexing problems in meteorology.

DESTRUCTIVE STORMS IN KENTUCKY, FEBRUARY 7, 1904.

By H. B. HERSEY, Inspector, Weather Bureau.

Very severe destructive local storms occurred at many places in Kentucky during the early morning hours of February 7, 1904.

In several localities these storms assumed the characteristics of a tornado. Occurring between 2 and 5 o'clock in the morning, when few people were awake, accurate description of the sky and clouds are not obtainable, but an examination of the effects of these storms shows that some of them were tornadoes.

While the season and time of day were not favorable to such storms, the pressure and temperature conditions were favorable. At 7 p. m. of February 6 there was an area of very low pressure central over Illinois, with secondary disturbances in Oklahoma and Colorado. These centers must have developed